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(54) MANUFACTURE OF COMPOSITE METALLIC PRODUCTS FROM POWDER

(71) We, BRITISH IRON AND STEEL RESEARCH ASSOCIATION, a British Company of 24, Buckingham Gate, London, S.W.1., do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the manufacture of metallic products from powder, and in particular to the manufacture of composite metallic products having two or more parts of differing metallic composition.

Composite metallic products are conventionally manufactured by the welding or brazing of two or more constituent parts. Known welding techniques included explosive welding, gas welding and furnace welding. In certain instances a composite metallic product may be made by the spraying of the exterior of one metal part with liquid metal of a different composition.

An example of a composite product made by welding is an austenitic steel tube welded via a transition joint to a ferritic steel tube. Duplex tubes of this nature are used in the power generation industry and in various chemical processes. A stainless steel clad mild steel tube may be manufactured by welding. This type of composite tube may be used where the external surface of the tube is subject to a corrosive atmosphere and the internal surface of the tube is not.

An example of a composite metallic product manufactured by spraying liquid metal of one composition onto a metal of another composition is in the manufacture of turbine blades. Turbine blades frequently require erosion shields at their tips, which erosion shields may be made of a hard-facing alloy material sprayed onto the blade surface. Alternatively the hard-facing alloy material can be furnace brazed onto the stainless steel blade.

The methods of manufacturing composite and metallic products so far mentioned suffer from various disadvantages. Transition joints between stainless steel and carbon steel are notoriously difficult to produce, and require a highly skilled welder, and have limited life. Turbine blades suffer from embrittlement problems adjacent to the surface of the blade when an erosion shield is brazed onto the blade.

According to one aspect of the present invention a method is provided of manufacturing composite metallic products having two or more parts of differing metallic composition which comprises the steps of, supporting a container of yieldable material within an open mesh holder, introducing a first metallic powder into the container to partly fill the container, introducing into the container a second metallic powder of composition different from that of the first adjacent to the first powder, subjecting the filled container within the holder to compression to produce a partly densified composite blank, sintering the blank and subsequently working the blank.

The container and its contents may be vibrated prior to compression in order to obtain better densification of the metallic powders. The container and its contents may additionally or alternatively be vibrated during the introduction of metallic powders.

In the accompanying drawings:—

Figure 1 shows in cross-section an elevation of one embodiment of apparatus for performing the present invention;

Figure 2 shows in cross-section an elevation of a second embodiment of apparatus for performing the present invention;

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Figure 3 shows schematically an isostatic compression chamber; and

Figures 4a and 4b show schematically two stages in the forward extrusion of a metallic blank.

Like numerals denote like parts in all the Figures.

In Figure 1, an open-mesh steel holder 10 of cylindrical shape has its upper end open and its lower end closed by a disc 11 which is perforated in several places. A steel support member 12 having a circular indented portion 13 rests on disc 11 and fits closely to the walls of holder 10. The support member 12 is also perforated.

A steel mandrel 14 is located at its lower end in the indented portion 13 of support member 12. The upper end of mandrel 14 is located by a steel former 15 which is perforated as shown.

A flexible container 16 (e.g. a bag of synthetic material such as rubber) fits closely inside holder 10, and is shaped at its lower end so that it fits between the bottom of mandrel 14 and the indented portion 13 of support member 12. The container 16 is folded over the upper end of holder 10 and is sealed by a flexible rubber seal 17 which is held in place by former 15. A sealing ring 18 fits around mandrel 14 at the point where the container 16 enters the indented portion of support member 12.

In use, a first metallic powder 19 is introduced into the container 16 from above, the flexible seal 17 and the former 15 being removed and replaced by a metal spider (not shown). The function of the spider is solely to hold the mandrel 14 in the correct position.

The first metallic powder 19 is for example a ferritic steel powder of 100 mesh size. The holder 10 is vibrated during the introduction of the powder 19 so that the powder packs well into the container 16. The sealing ring 18 prevents powder 19 entering the space defined between the mandrel 14 and the opposed surface of the container 16.

A second metallic powder 20, for example an austenitic stainless steel powder is then introduced into the container 16, the holder 10 being vibrated during its introduction. The spider is removed and the flexible seal 17 and former 15 then fitted across the top of holder 10.

The holder 10 and its contents are then transferred into a compression chamber 30 (shown schematically in Figure 3) and placed on a support 31. Hydraulic liquid 32 is admitted to the chamber 30 through entry port 22 until the chamber 30 is full. Excess liquid leaves the chamber 30 by exit port 33. Liquid 32 is then compressed to a pressure of about 30,000 lb. per sq. in., the exit port 33 being closed. This pressure is transmitted isostatically over the holder 10 and its contents, and effectively compresses the powders 19 and 20 to form a partly densified composite tube blank. During compression the hydraulic liquid 32 enters the holder through the open mesh of its surface and presses the container 16, which is yieldable, against the powder 19 and 20. The perforated former 15 allows liquid 32 to press against the flexible seal 17 which stretches downwardly as the powder 20 occupies a decreasing volume. It will be appreciated that the example does not show true isostatic compression since the powders 19, 20 are not compressed from the mandrel side by the hydraulic liquid. In another embodiment (not shown) it would be possible to have a perforated mandrel and an annular yieldable container, in which case true isostatic compression of the powders 19, 20 could be achieved.

The partly densified composite tube blank produced by isostatic compression is subsequently removed from holder 10 and mandrel 14 and heated in a furnace of known type to a temperature suitable for hot extrusion.

In Figures 4a and 4b a partly densified hot tube blank 40 is shown in the process of forward extrusion. The blank 40 is forced by ram 41 through a die 42 supported in die ring 43. The ram 41 has a forward extending member 44 of smaller diameter than the die 42 which extends into the die 42 at the beginning of the extrusion operation. The blank 40 is thus forced between the die 42 and the forward extruding member 44 to form a tube 45.

The composite tube 45 made by this process will have one half made of ferritic steel and the other half made of austenitic stainless steel.

In the embodiment of the invention shown in Figure 2 the first and second powders 19 and 20 respectively are separated by a cylindrical membrane 21 which may be removed prior to compression of the powders 19 and 20 within the holder 10. The membrane may be made of a carbonaceous consumable material such as polythene or stiff paper. The arrangement of the powders 19 and 20 in this embodiment is such that when the holder 10 and its contents are compressed, a tubular blank is produced having two co-axial annuli of differing metallic composition. When this blank is heated and extruded, a tube is produced having an outer layer of differing composition from the inner layer.

In the embodiment of Figure 1, a membrane may also be used to separate the

powders having differing metallic composition. The membrane, being of polythene or paper, degrades or decomposes when the partly densified blank is heated to allow sintering between parts of differing metallic composition.

Metal products other than tubes may be made by this process, for example, composite metal sections or bars. Two or more powders of differing metallic composition can be used if one wishes to produce a sandwich type of construction. For example a tube having a stainless steel outer and inner surface, but a carbon steel core may be produced in this way.

WHAT WE CLAIM IS:—

1. A method of manufacturing composite metallic products having two or more parts of differing metallic composition which comprises the steps of,
supporting a container of yieldable material within an open mesh holder, introducing a first metallic powder into the container to partly fill the container,
introducing into the container a second metallic powder of composition different from that of the first adjacent to the first powder,
subjecting the filled container within the holder to compression to produce a partly densified composite blank,
sintering the blank and subsequently working the blank.

2. A method as claimed in claim 1 in which a membrane is provided to separate the second metallic powder from the first metallic powder during the introduction of the metallic powders.

3. A method as claimed in claim 2 in which the membrane is removed from the container prior to the compression of the container and its contents.

4. A method as claimed in any of the preceding claims in which the container and its contents are vibrated prior to compression.

5. A method as claimed in any of claims 1 to 3 in which the container and its contents are vibrated during the introduction of the metallic powders.

6. A method as claimed in claim 2 and in claims 3 to 5 when dependent on claim 2 in which the membrane is of carbonaceous material.

7. A method as claimed in any of the preceding claims in which the blank is hot extruded.

8. A method as claimed in any of the preceding claims in which the first metallic powder fills an annular space defined about a mandrel positioned centrally within the container.

9. A method as claimed in any one of claims 1 to 7 in which the first and second metallic powders form coaxial annuli about a mandrel positioned centrally within the container.

10. A method as claimed in any preceding claim in which the container and its contents are subjected to isostatic compression.

11. A method of manufacturing composite metallic products having two or more parts of differing metallic compositions substantially as herein described with reference to Figure 1 or Figure 2 of the accompanying drawings.

12. A composite metallic product manufactured by a method as claimed in any one of the preceding claims.

13. Apparatus when used for carrying out the method of claim 1 comprising a cylindrical open mesh holder which is closed at its lower end by a perforated disc and a container of yieldable material positioned within the holder for receiving metallic powders of different composition.

14. Apparatus as claimed in claim 13 further comprising a membrane for separating metallic powders of differing composition located within the container.

15. Apparatus as claimed in claim 14 wherein the membrane is of a carbonaceous material.

16. Apparatus as claimed in claim 13 wherein a perforated support member having a central circular indented portion is mounted on the disc and within the holder.

17. Apparatus as claimed in in claim 16 wherein an upstanding mandrel is supported at its lower end within the indented portion of the support member and is supported at its upper end by means of a perforated metallic former which closes the upper open end of the holder.

18. Apparatus when used for manufacturing composite metallic products having two or more parts of differing metallic composition by the method claimed in claim 1 and substantially as herein described with reference to Figure 1 or Figure 2 of the accompanying drawings.

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FIG. 1.

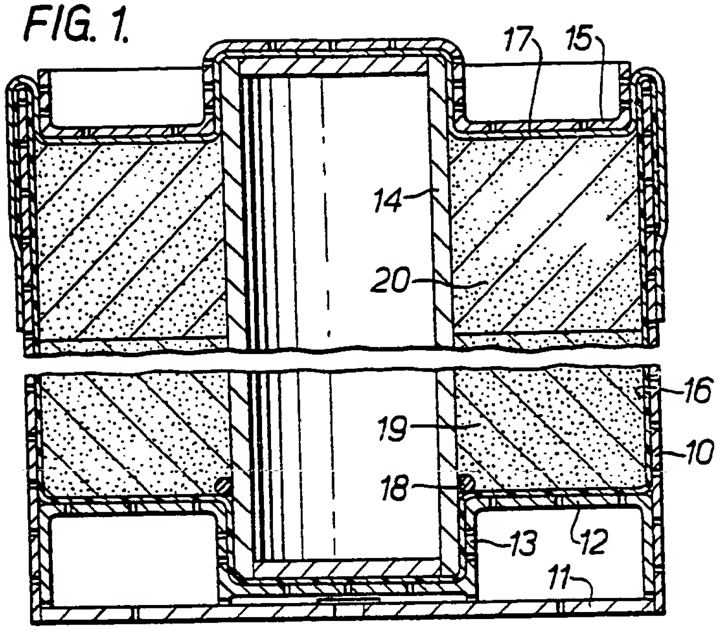

FIG. 2.

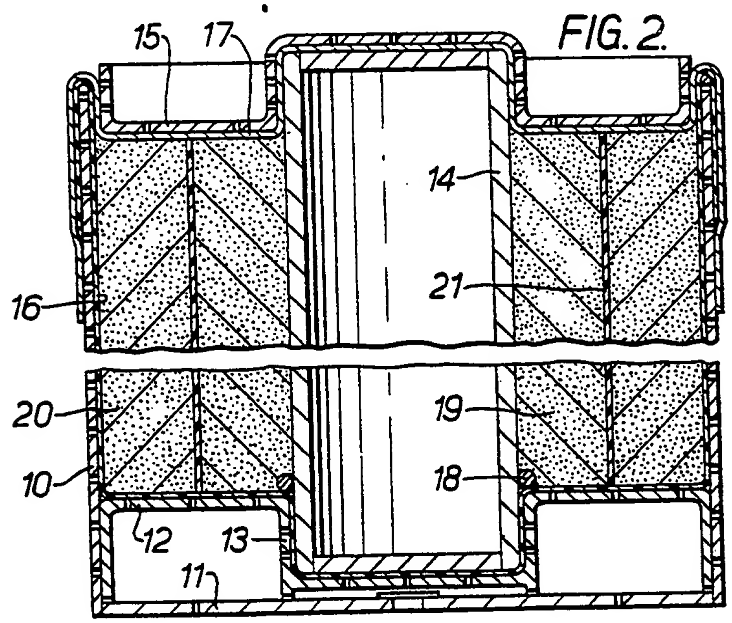

FIG. 3.

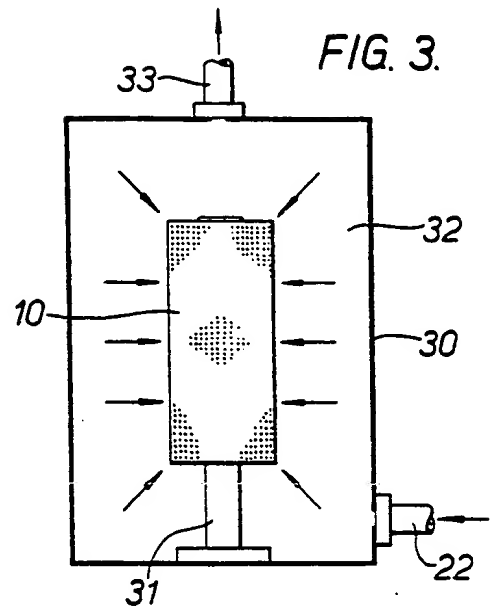

FIG. 4A.

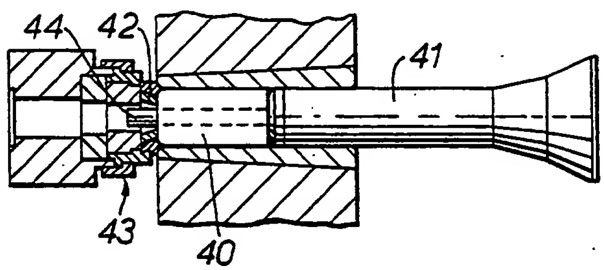

FIG. 4B.